RECOMMENDATIONS FOR IMPROVED SHUTTLE-CAR-HAULAGE SAFETY

BY D. S. KINGERY

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SUMMARY

Investigations over several years have disclosed that the principal manners of occurrence of shuttle-car injuries are in order:

1. Victims in contact with roof or crossbars.
2. Victims in contact with ribs or timber legs.
3. Victims falling from, or jerked from, shuttle cars.
4. Victims in contact with overhanging brows or protruding pins for pin timbers, or water lines.
5. Contact with persons or collisions with parked equipment.
6. Victims injured by roof falls or falling timbers caused by knocking out roof supports with shuttle cars.
7. Victims injured by runaway shuttle cars.
8. Victims injured while loading or unloading timbers or other materials from shuttle cars.

These recurring types of shuttle-car accidents reflect the physical conditions of the working sections, certain safety deficiencies in shuttle-car maintenance and design, and unsafe practices by operators.

INTRODUCTION

The widespread acceptance of shuttle-car haulage by the bituminous-coal-mining industry has been rapid. Within 14 years, this type of haulage has become so prominent that approximately 50 percent of the mobile loading machines now in service load into shuttle cars.

This innovation in face-haulage methods has reduced some hazards common to track haulage; it also has contributed others inherent in shuttle-car operations.

The injury-frequency rate for persons injured by shuttle cars is approximately twice that of all bituminous-coal-mine accidents, indicating the need for study and corrective measures to reduce shuttle-car accidents.

This circular is based upon suggestions and recommendations submitted by more than 200 Federal coal-mine inspectors stationed throughout the bituminous-coal-producing States. It is expected that this information will help coal-mine safety engineers, mine managers, safety committeemen and supervisory officials in their efforts to prevent shuttle-car accidents

FACTORS CONTRIBUTING TO SHUTTLE-CAR ACCIDENTS

The more prevalent factors contributing to shuttle-car accidents are as follows:

Physical Conditions

1. Shuttle-car roadways of inadequate width and/or with timber legs protruding into the haulageway.
2. Shuttle-car roadways containing chuck holes, ruts, or other irregular conditions. Such roadways usually are poorly drained.
3. Coal ribs irregular and with excessive overhang.
4. Check curtains installed at narrow points, at jutting brows, or at entrances to breakthroughs.
5. Unsuitable timbering system, increasing shuttle-car operating hazards.
6. Attempted use of shuttle cars too high for the height of coal without taking bottom or top.
7. Makeshift shuttle-car unloading ramps or discharge points lacking adequate lighting or headroom and without safety features, such as stop blocks or ramp cleats.
8. Unsuitable mining plans, utilizing hit-or-miss mining control and operations.

Apparent Deficiencies in Shuttle-Car Maintenance and Design

1. Defective or deficient brakes or steering mechanism.
2. Defective or deficient lighting arrangement.
3. Lack of auxiliary brakes.
4. Exposed operator's space, lacking comfort and often requiring strained positions tiring to the operator.
5. Lack of audible warning devices.
6. Protruding boxes or corners that catch timber sets and check curtains.

Common Hazardous Operating Practices

1. Not facing direction of travel.
2. Operating shuttle cars while exposed or not fully seated.
3. Pushing or bumping shuttle cars with loading machines during loading.
4. Excessive speed for physical condition of travelways.
5. Jumping off moving equipment.
6. Failure to sound audible warnings and to be alert while approaching check curtains, doors, or workmen.
7. Horseplay on or around shuttle cars.
8. Use of shuttle cars by unauthorized or inexperienced personnel.

DISCUSSION OF IMPORTANT CONSIDERATIONS FOR SHUTTLE-CAR SAFETY

Shuttle cars partially replace gathering locomotives, mine cars, and track at the initial stages of coal-mine haulage. There are both advantages and disadvantages in using them. Some advantages are: Reduced car-change time, greater concentration of operation, increased speed of advance work, reduction of some deadwork, and decrease in mine-track installation, maintenance, removal, and salvage. The more apparent disadvantages are: More-difficult roof control, with problems of ventilation, dust control, and drainage. Of significant importance is the need for accurate mine projection, good cutting practices, straight sight lines, and preparation on cycle, as well as the maintenance of roadways, equipment, and the need for stable, dependable operators.

Operating Conditions

There has been a general tendency for the mining industry to compare the operation of shuttle cars with that of vehicles on roads or highways. The problems, however, are only remotely similar; the automobile or truck driver generally has a comfortable seat, unlimited overhead clearance, good visibility, adequate side clearance, and an enclosed, protected cab with controls operated in a standard conventional manner. The shuttle-car operator usually works from an unprotected seat in a cramped, tiring position, and the overhead clearance may be so limited that he often is operating blind. Haulage roads may be wet, muddy, and obstructed with miscellaneous debris or supplies and have limited side clearance, with dangerous hazards at intersections. The visibility is poor at best, and certain types of shuttle cars require the operator, when reversing direction, to steer and brake opposite from conventional automobile practices. These restrictions and conditions illustrate many of the operating hazards and partly explain the high injury-frequency rate of shuttle-car personnel.

The Mining Plan

Failure to establish long-range planning and accurate projections, based upon known natural conditions, contributes materially to the hazards of shuttle-car operation. Natural conditions often dictate the success or failure of the enterprise, since these conditions govern the practical width of entries, the timbering requirements, roadway grades, drainage, and overhead clearance. The mining plan should be laid out to facilitate operations by minimizing sharp turns and providing the maximum width of haulage roads consistent with good roof control. It should include projections for track-loading points, keeping the tramming distances at a minimum, and show the locations of power lines, power-connection stations, designated travelways, and ventilation. The plan should remove as much guesswork as possible from sectional operations.

The Timbering Plan

Failure to maintain a suitable timbering plan has been responsible for numerous shuttle-car accidents. Shuttle-car haulage, by nature of wide shuttle cars not confined to any exact roadway, necessitates the maximum lateral clearance between timber supports. The commonest practices have been to use crossbars set on carrying bars supported by legs, pin timbering, or roof bolting. Where crossbars set on legs are employed, it has not been the general practice to recess crossbar legs or tie them together by means of stringers. Moreover, in many mines the crossbars vary somewhat in length, and short crossbars set on single legs often are used. The timbering may be done in a perfunctory manner, not set for effectiveness but to satisfy company or State regulations. These factors add to the operators hazards and quite often account for shuttle cars striking or knocking out roof supports. Pin timbering, if properly done, and roof bolting reduce much of this danger and add to shuttle-car safety.

Overhead Clearance

Lack of overhead clearance is a very important detriment to safety and efficient operation. There has been, however, a tendency at many times to install shuttle cars that are too large for natural or established conditions. This condition is quite often due to the following causes:

1. Transferring shuttle cars within companies from a relatively high coal bed to a bed of lower coal.

2. Purchasing second-hand equipment on the open market, with consideration only for cost and rated capacity.

3. Unusual undulation of the coal bed, reducing overhead clearance in certain sections.

4. Purchasing new equipment on the basis of average coal-bed height, without first obtaining complete data on natural conditions.

5. Purchasing new equipment on the basis of its rated capacity only, with little thought for its underground suitability.

Limited overhead clearance influences the operation by complicating the timbering system, reduces visibility and operating speed, increases fatigue with resulting ineffectiveness of the operator, and adds to the danger from poor haulage roads, as well as contributing many other deleterious effects.

These factors often are not considered in selecting oversize shuttle-cars. Their effect constitutes a poor substitute for the extra shuttle car capacity, especially as this advantage often is not realized.

Roadway Maintenance

Poorly drained, muddy, rutted, irregular roadways contribute to many shuttle-car injuries and definitely impede production. Roadway drainage at many mines is accomplished by ditching, or cutting sumps at low spots with the cutter bar of a mining machine and removing the water accumulations by pipe lines. When the bottom disintegrates into mud, several companies dump bone-coal refuse, then pack it down by the caterpillar treads of face equipment. Corduroy surfacing has been used for heavy mud or gumbo with fair success. Bottom rolls improperly leveled, chuck holes, dried ruts, and excessive spillage are common hazards that should be prevented.

Housekeeping and Supervision

Poor housekeeping reflects the supervision and indicates perfunctory work, high accident frequency, poor production, and a poor concept of shuttle-car mining. Shuttle-car haulage necessitates good housekeeping and the best available supervision. Excessive spillage, hit-or-miss supply storage and handling, and poorly hung check curtains all increase the operational hazards. Straight entries of regular width, even vertical ribs, turn-outs at proper intervals, and well-timbered places cannot be obtained unless the foreman appreciates their importance and constantly is alert to effect them.

Shuttle-Car Design and Maintenance

Modern shuttle cars are greatly improved by comparison with the original ones used; however, numerous older types of shuttle cars are still in service, and the new types lack certain desirable safety features. The following discussion covers a few of the most important considerations and applies to experience with shuttle cars of different makes. It is appreciated that some of the items discussed have been installed on the newer shuttle cars now available.

Brakes

Automobile-type brakes have not proved suitable, because the brake lining quickly fails in mud and water. Brake lining also may fold, locking the drum of one wheel which may place such a severe strain that the hydraulic system may burst, leaving the car without braking action. This deficiency has been corrected by some mining companies and the manufacturers by installing "aircraft"-type brakes that wear better and give more positive action. There is often a need for emergency brake action separate from the regular brake system. This can be provided by means of dynamic brakes capable of operating with the power connected or off. Shuttle cars thus equipped are available but not generally used.

Cable Reels

Many electric-driven type cable reels have proved excessively hard on trailing cables; these can be converted to hydraulic-operated-type reels, which have proved quite satisfactory and greatly extend the life of training cables. Cable strain caused by normal jerking of the trailing cable is conducive to excessive cable damage, with accompanying hazards. This trouble can be reduced by installing spring-type shock absorbers at the nip end of trailing cables.

Electrical Failures

Much of the cable failure experienced by shuttle cars can be attributed to undersized cables and oversized fuses. Failure to advance the track loading points at reasonable intervals in many mines has led to long tramming distances, necessitating small-diameter trailing cables with insufficient current-carrying capacity. This brings about excessive heating, which, combined with normal abuse and the lower mechanical strength of the cable, causes numerous cable failures and blow-ups. Abuse of trailing cables by scraping along sharp corners and being run over by face equipment can be reduced by a little planning of haulage routes.

Safety may be improved by suspending the cables and preventing sharp-angle turns. At many mines it has been the practice to install the same-ampere fuses on shuttle-car trailing nips that are used on loading or sometimes mining machines, destroying the protection of the fused nips. Safety protection from electrical shock due to wiring failure or a low-resistant short of the trailing cable can be provided by installing circuit centers supplying ground trip relay protection. These open the circuit at a preset low-amperage ground flow. Little thought has been given to the hazards resulting from reversed polarity, since it becomes evident only under specific conditions. A definite danger exists, however, when the positive wire is accidently spliced to the negative and a ground develops between the coil and switch. Under these conditions, the car will not respond to the switch if in motion; if it is standing when a ground failure develops, the car will start of its own accord.

Maintenance

"Preventive maintenance" of equipment is a "must" for safe, efficient operation. It is very easy to consider maintenance a production problem and operate equipment until it fails, excusing delays or resulting accidents to unavoidable circumstances. This fallacious reasoning is reflected in disappointing production and high accident rates. Progressive companies endeavor to prevent mechanical or electrical failures by a continuing system of daily inspection and repair. Some companies keep accurate records of coal hauled, the time equipment is in service, and the repairs made; at predetermined time intervals, equipment units are taken out of service and completely rebuilt.

Shuttle-Car Operating Personnel

Probably the most-important consideration for shuttle-car safety is the selection and training of personnel. It is appreciated that, throughout the coal-mining industry, the most-suitable men are not always available and that senority rules sometimes hinder selections. The goal, however, should be to select men of small or medium size, known to have stable temperment, be cooperative, and have quick mental and physical reflexes. Enough training should be given to acquaint each new man with shuttle-car operation procedure and the inherent hazards of his job. Some companies accomplish this by staking out training areas outside the mine, marking off entries, rooms, and intersections. This permits a new employee to become familiar with equipment and to develop proficiency without danger. Other companies conduct training underground under supervision of experienced personnel. In either method, a prospective operator must demonstrate aptitude and ability to control a shuttle car before he is assigned to a regular run. This type of training, although considered a minimum, if combined with adequate, alert supervision, regular job instructions, and enforced practical safety regulations, will help to reduce shuttle-car accidents.

RECOMMENDED SAFE PRACTICES FOR SHUTTLE CAR OPERATORS

1. At the start of each shift, operators should check the mechanical performance of shuttle cars, including brake action, steering, lights, cable-reel operation, tire inflation, and general operating performance.

2. At the start of each shift, the operator should make a trial run through the section, observing changes from his previous shift, checking overhanging ribs, hazardous timber sets, bad spots on the roadway, location of check curtains, stored material, low overhead clearance, and other hazards.

3. Operators should face the direction of travel, except while maneuvering back of the loading machine.

4. Shuttle cars should not be pushed or bumped by loading machines during loading.

5. A standard code of audible signals between the shuttle-car and loading-machine operators should be established and practiced.

6. During loading, a shuttle-car operator should remain seated and alert, with complete control over the shuttle car.

7. No one other than an operator, or experienced personnel expressly designated, should move or operate shuttle cars.

8. The operator should be seated and have complete control over the shuttle car while it is in motion.

9. The operator should not get off a shuttle car while it is in motion.

10. No persons should ride in the bed of shuttle cars.

11. The operator trailing another shuttle car should maintain a distance of three car lengths.

12. Where materials are hauled on shuttle cars, a locking device should be installed to prevent accidental movement of the flight chain.

13. An operator should approach check curtains, intersections, and other locations where vision is obstructed with caution; audible warning signals should be sounded.

14. An operator should not try to change seats while the shuttle car is in motion.

15. An operator should be sure that all persons are clear and should sound a warning before he moves the shuttle car.

16. Shuttle cars should be operated at a speed regulated by the condition of the roadway, overhead clearance, visibility, obstructions, and traffic. The shuttle car should never exceed 4 miles per hour.

17. An operator should not attempt to pass anyone while traveling on curves or turns.

18. An operator should keep the cab free of debris or other material that might cause controls to stick or interfere with operations.

19. Controls should be operated only while the operator is in his cab.

20. When a lift is used to raise a shuttle car, blocking should be used to support the car before any person is permitted to work under or around it.

RECOMMENDATIONS TO IMPROVE PHYSICAL CONDITIONS

1. Shuttle-car roadways should be of adequate width, dry, reasonably level, and free from ruts, chuck holes, or other obstructions.

2. Coal ribs in shuttle-car sections should be maintained free from overhanging coal or other protrusions.

3. Special attention should be given to timbering shuttle-car intersections, assuring adequate maneuvering space. Carrying bars should be set with two posts at each end, and protruding legs should be recessed, or guard-rail stringers tying the legs together should be used.

4. Where check curtains are installed on haulage roads, they should be placed across straight parts of the entry and not by jutting brows or crosscuts.

5. Ventilation controls, such as check curtains or doors, should be removed when no longer needed.

6. Shuttle-car unloading ramps should be of solid construction, considerably wider than the distance between wheels, and provided with cleats, curbs, and a block to prevent the car from falling off.

7. Shuttle-car discharge points should be well-lighted, maintained reasonably free from coal spillage and have ample headroom.

8. Power wires at unloading stations should be installed in a manner that prohibits the possibility of contact with shuttle cars or operators.

9. Sharp-angle haulage-road turns should be reduced the maximum extent possible.

10. Timber, pipe, tools, or other supplies should not be stored along the haulage road in a manner that causes obstructions or limits travel.

11. Good housekeeping, with regular removal of coal spillage and orderly storage of material should be practiced.

12. Shuttle-car roadways that become soft should be corduroyed or filled with suitable refuse material.

13. In dry, dusty areas, protection against dust accumulations on the roadway should be provided by applying calcium chloride or water.

SUGGESTED SAFETY-DESIGN FEATURES FOR SHUTTLE CARS

It is recognized that many of the following suggestions are incorporated or available in the newer types of shuttle cars and that improvement in design is a continuing process by manufacturers of mining equipment. It is also appreciated that certain of these recommendations reflect the maintenance and condition of the equipment at the time the inspector saw it and such are the basis for his suggestions. The following list consequently includes features that have long been recognized as important but are missing from many of the shuttle cars in service, as well as new considerations not yet generally accepted by manufactures of equipment.

1. All shuttle cars should be provided with audible warning devices.

2. Cable reels should be of hydraulic type, to prolong the life of trailing cables.

3. Shock absorbers to prevent excessive cable strain should be used.

4. Airplane-type disk brakes should be used as an improvement over the conventional automobile type.

5. Some electrical control unit should be installed to prevent contactors from operating when a wrong splice is made and polarity reversed.

6. Shuttle cars should be equipped with dim lights to be used during loading.

7. Headlights should be provided on each end of a shuttle car; transfer of lights to the direction of travel should be automatic.

8. Shuttle cars should be painted a distinctive color that reflects maximum light.

9. The power-control switch and brake pedal should be so arranged that the operator will use the same foot, regardless of the direction of travel.

10. Emergency brakes operated from a separate brake system should be available.

11. Where necessary, a cover guard should be provided on the "airplane" brake system to minimize cable ruptures from back-acting cables.

12. Grab irons should be installed for emergency protection of the operators.

13. Circuit breakers or other protection should be provided against electric shock from ground currents.

14. The operator's cab should permit reasonable seating and operating comfort and allow the operator to see without working from a strained hazardous position.

15. Fire extinguishers should be provided on all shuttle cars.

16. The operator's cab should be guarded as a protection against collision with ribs or timbers.

17. The metal plates by the operator's head, or other danger zones, should be padded.

18. Rounded bumpers should be provided to prevent square corners of the car from catching coal ribs or dislodging timber legs.

19. A safe clearance switch should be provided that will automatically stop the car on contact with coal ribs or timbers.

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